

Lunar Flashlight

Completed Technology Project (2014 - 2018)



Project Introduction

Lunar Flashlight (LF) is an innovative CubeSat mission to be launched on the Space Launch System (SLS) EM-1 flight as a secondary payload. LF is dedicated to locating water ice in the permanently shadowed regions of the lunar south pole by measuring surface reflectance at multiple wavelengths. LF will be one of the first cubesats performing science measurements beyond low Earth orbit and the first planetary mission to use multi-band active reflectometry from orbit.

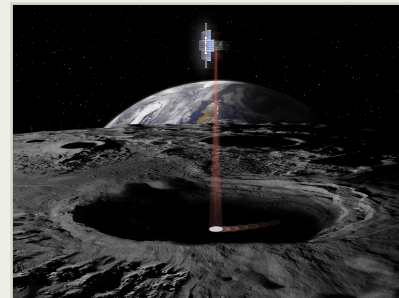
The Lunar Flashlight (LF) mission is a NASA 6U (6 Units of approximately 10×10×10 cm each) cubesat mission dedicated to mapping water ice in the permanently shadowed regions within 10° latitude of the lunar south pole. The measurement approach utilizes a multi-band reflectometer in orbit at the Moon. Planned to launch on the SLS EM-1 flight, this innovative secondary payload concept will begin to map the lunar south pole for volatiles and demonstrate several technological firsts, including being the first CubeSat to orbit the Moon, the first planetary CubeSat mission to use green propulsion, and the first mission to use lasers to look for water ice.

Locating ice deposits in the Moon's permanently shadowed craters addresses one of NASA's Strategic Knowledge Gaps (SKGs) to detect composition, quantity, distribution, form of water/H species and other volatiles associated with lunar cold traps. The scientific and economic importance of lunar volatiles extends far beyond the question "is there water on the Moon?" Volatile materials including water come from sources central to NASA's strategic plans, including comets, asteroids, interplanetary dust particles, interstellar molecular clouds, solar wind, and lunar volcanic and radiogenic gases. The volatile inventory, distribution, and state (bound or free, evenly distributed or blocky, on the surface or at depth, etc.) are crucial for understanding how these molecules interact with the lunar surface, and for utilization potential.

The LF science goal is to identify locations where water ice may be present at concentrations $\geq 0.5\text{wt}\%$ (0.5 weight %) on the lunar surface with a mapping resolution of 1-2 km (10 km for the minimum success criteria). During the planned 2-month primary mission, LF will pulse the lasers for several minutes from each of 11 near-rectilinear orbits, at altitudes of 12.6-52.4 km within 10° latitude of the lunar south pole.

Lunar Flashlight is an exciting new mission concept that was recently selected by NASA's Advanced Exploration Systems (AES) by a team from the Jet Propulsion Laboratory, UCLA, and Marshall Space Flight Center. Planned to launch on the SLS EM-1 flight, this innovative, low-cost secondary payload concept will map the lunar south pole for volatiles and demonstrate several technological firsts, including being the first CubeSat to reach the Moon, the first planetary cubesat mission to use green propulsion, and the first mission to use lasers to look for water ice.

Locating ice deposits in the Moon's permanently shadowed craters addresses



Lunar Flashlight Operational Concept over Lunar South pole.

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The Lunar Flashlight mission spacecraft maneuvers to its lunar polar orbit and uses its near infrared lasers to shine light into the shaded polar regions, while the on-board spectrometer measures surface reflection and composition. The Lunar Flashlight 6U spacecraft has heritage elements from predecessor systems including JPL's INSPIRE and JPL's experience with imaging spectrometers, including the Moon Mineralogy Mapper (M3). The mission will demonstrate a path where 6U CubeSats could, at dramatically lower cost than previously thought possible, explore, locate and estimate size and composition of ice deposits on the Moon. It is a game-changing capability for expanded human exploration, planetary science, heliophysics, and other relevant instrument applications.

Polar volatile data collected by Lunar Flashlight could then ensure that future exploration targets for more expensive lander- and rover-borne measurements would include volatiles in sufficient quantity and near enough to the surface to potentially be operationally useful.

This technology development activity was transferred to the STMD Small Satellite Technology Program in October 2018.

Anticipated Benefits

The Lunar Flashlight payload consists of an optical receiver aligned with four lasers, which sequentially emit 1 ms pulses with optical output powers of 10-35 W. Each laser will emit in a different wavelength band centered in the NIR spectral region: 1.064 μm +/- 20 nm, 1.495 μm +/- 20 nm, 1.85 μm +20/-30 nm and 1.99 μm +25/-20 nm with a maximum FWHM (Full width at Half Maximum) of 20 nm. These wavelengths correspond to peak absorption wavelengths for water ice and nearby continuum wavelengths. The optical receiver collects and measures a portion of the laser light reflected from the lunar surface; reflectance and continuum/absorption reflectance band ratios are then analyzed to quantify water ice in the illuminated spot.

The green propellant propulsion subsystem provides the capability for LF to insert into a lunar orbit while the laser spectrometry payload enables taking

Organizational Responsibility

Responsible Mission Directorate:

Exploration Systems Development Mission Directorate (ESDMD)

Lead Center / Facility:

Jet Propulsion Laboratory (JPL)

Responsible Program:

Exploration Capabilities

Project Management

Program Director:

Christopher L Moore

Project Manager:

John D Baker

Principal Investigator:

Barbara A Cohen

Co-Investigator:

Paul O Hayne

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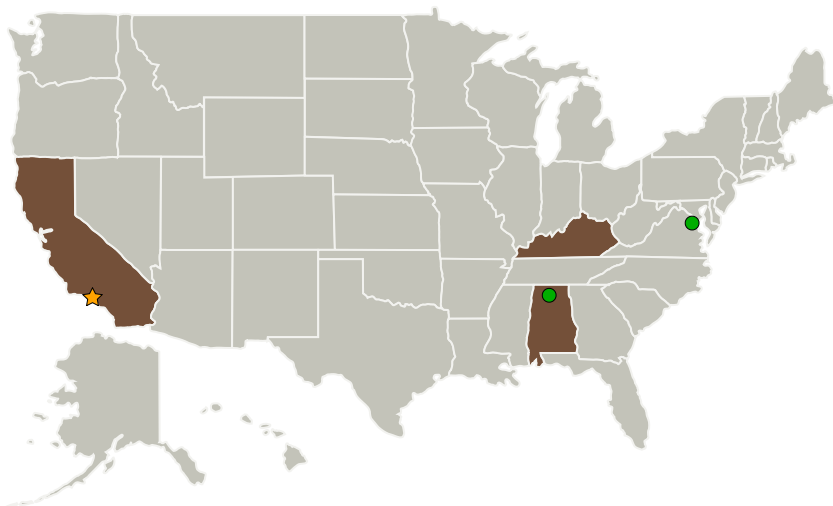
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the measurements of water ice to address the SKG.

Polar volatile data collected by Lunar Flashlight could ensure that future exploration targets for more comprehensive lander- and rover-borne measurements would include volatiles in sufficient quantity and near enough to the surface to potentially be operationally useful. For example, knowing the concentration of water-ice in PSRs can help decide where to establish a lunar base since the water can be mined to be used as a source of fuel and drinking water for astronauts.

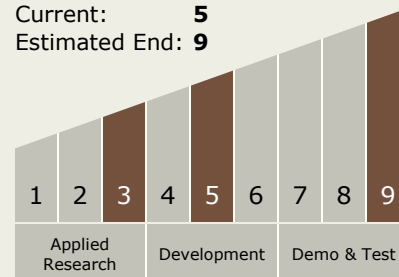
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★ Jet Propulsion Laboratory(JPL)	Lead Organization	NASA Center	Pasadena, California
● Marshall Space Flight Center(MSFC)	Supporting Organization	NASA Center	Huntsville, Alabama
Morehead State University	Supporting Organization	Academia	Morehead, Kentucky
● NASA Headquarters(HQ)	Supporting Organization	NASA Center	Washington, District of Columbia

Technology Maturity (TRL)

Start: 3
Current: 5
Estimated End: 9



Technology Areas

Primary:

- TX07 Exploration Destination Systems
 - TX07.1 In-Situ Resource Utilization
 - TX07.1.1 Destination Reconnaissance and Resource Assessment

Target Destination

The Moon

Supported Mission

Type

Planned Mission (Pull)

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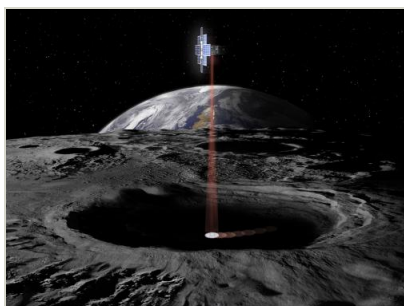
Primary U.S. Work Locations

Alabama	California
District of Columbia	Kentucky

Project Transitions

-  **September 2014:** Project Start
-  **September 2018:** Closed out
- Closeout Summary:** This AES project was transferred to the NASA Space Technology Mission Directorate (STMD) as of October 2020.

Images



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Lunar Flashlight Operational
Concept over Lunar South pole.
(<https://techport.nasa.gov/image/38022>)

Links

CubeSat for investigating ice on the Moon
(<http://spie.org/newsroom/technical-articles/6241-cubesat-for-investigating-ice-on-the-moon?highlight=x2404&ArticleID=x117007>)